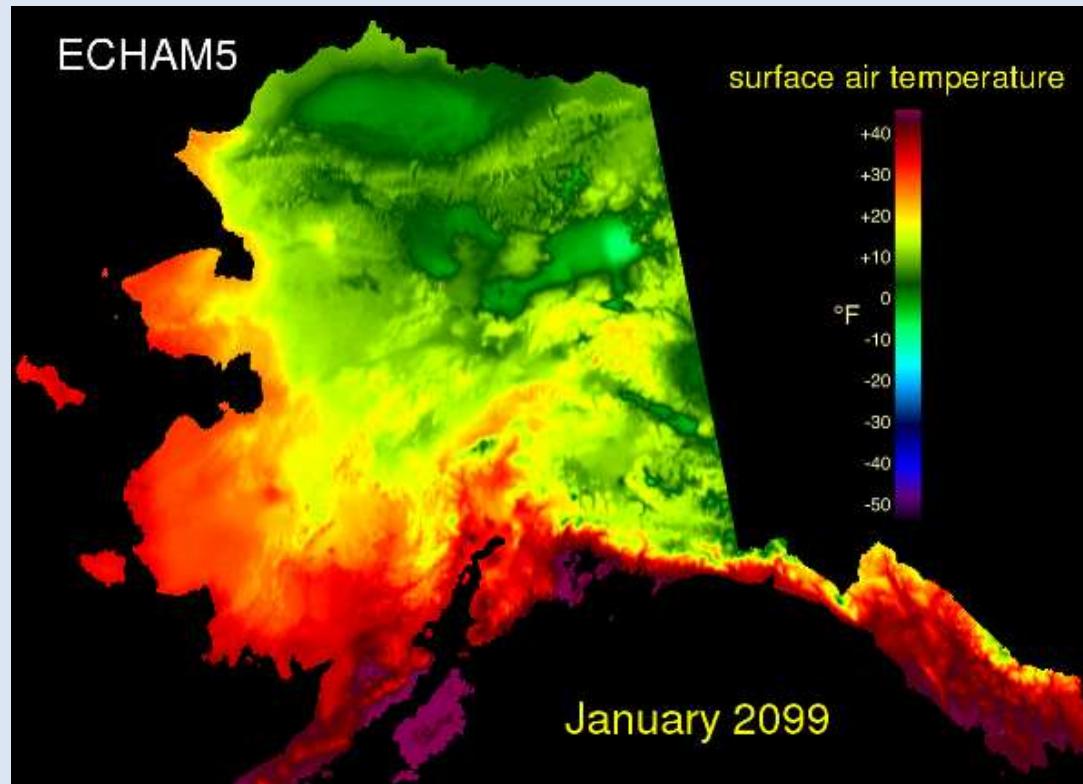


Alaskan Climate Futures: Drivers and Uncertainties



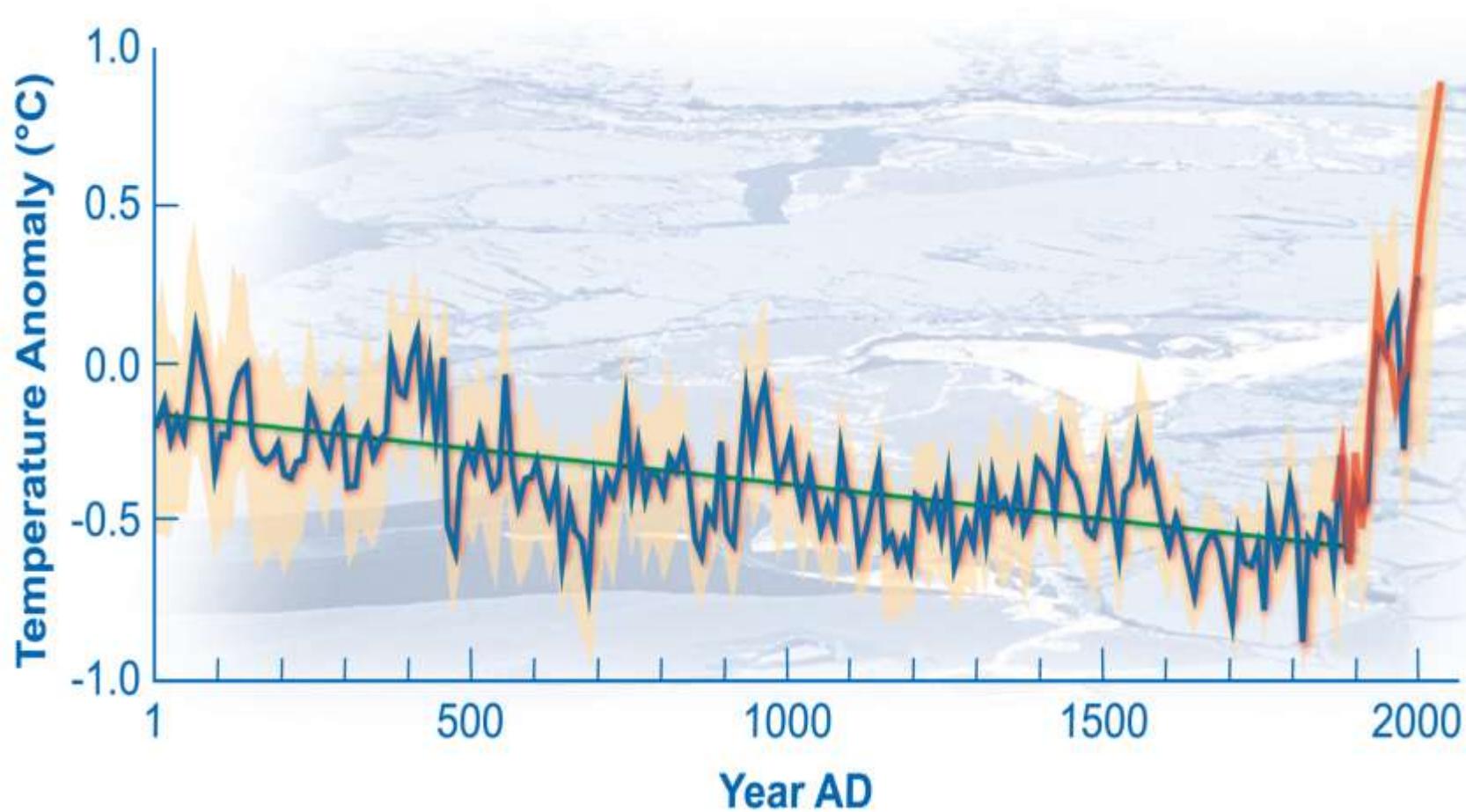
John Walsh, Scott Rupp, Nancy Fresco

UAF/SNAP (Scenarios Network for Alaska and Arctic Planning)

NPS Workshop, March 2012

Reconstruction of summer Arctic temperatures

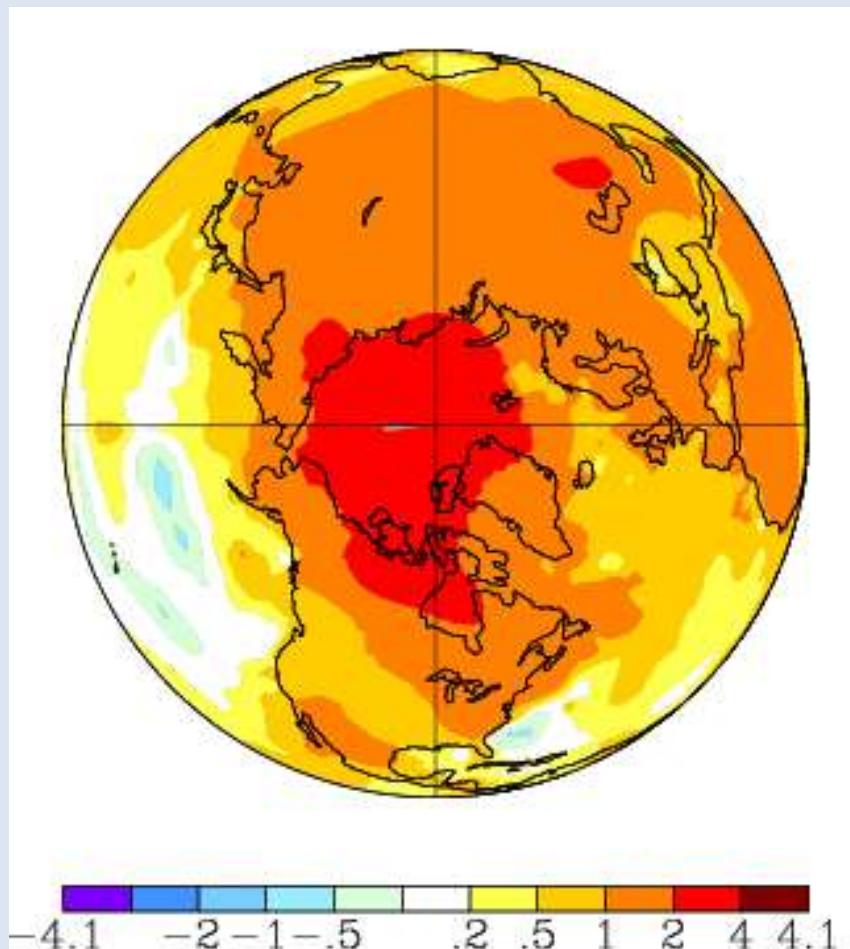
[Kaufman et al., 2009, Science]



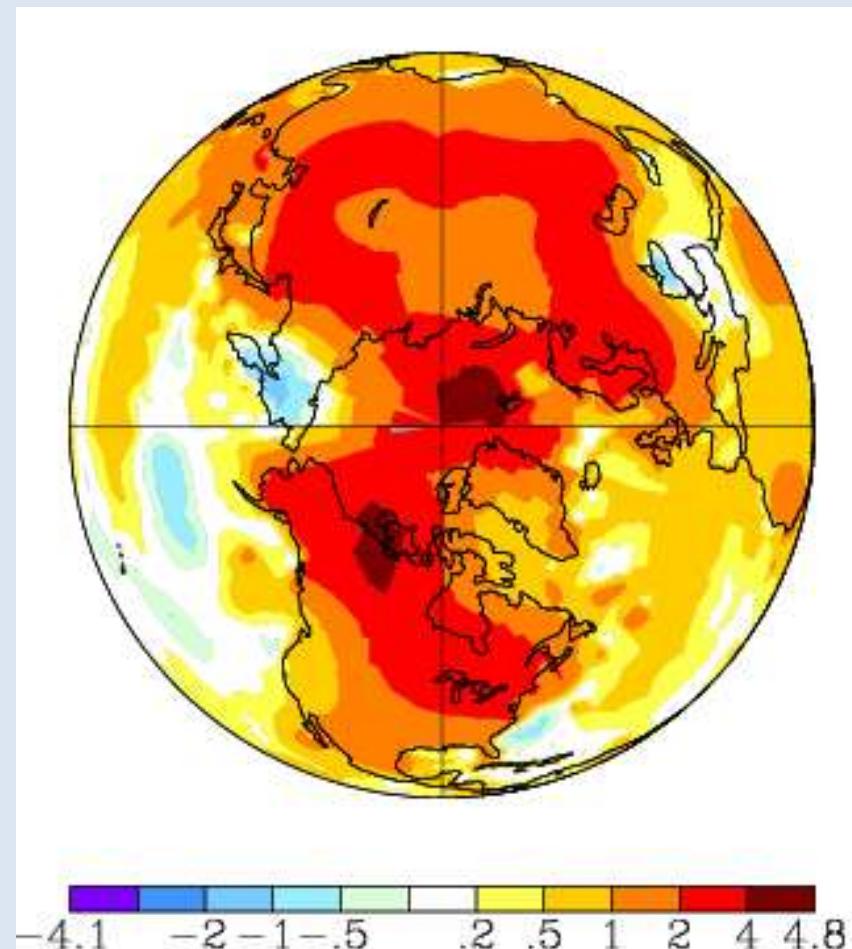
Change in Arctic surface air temperature (°C), 1961-2010

[from NASA GISS]

Annual



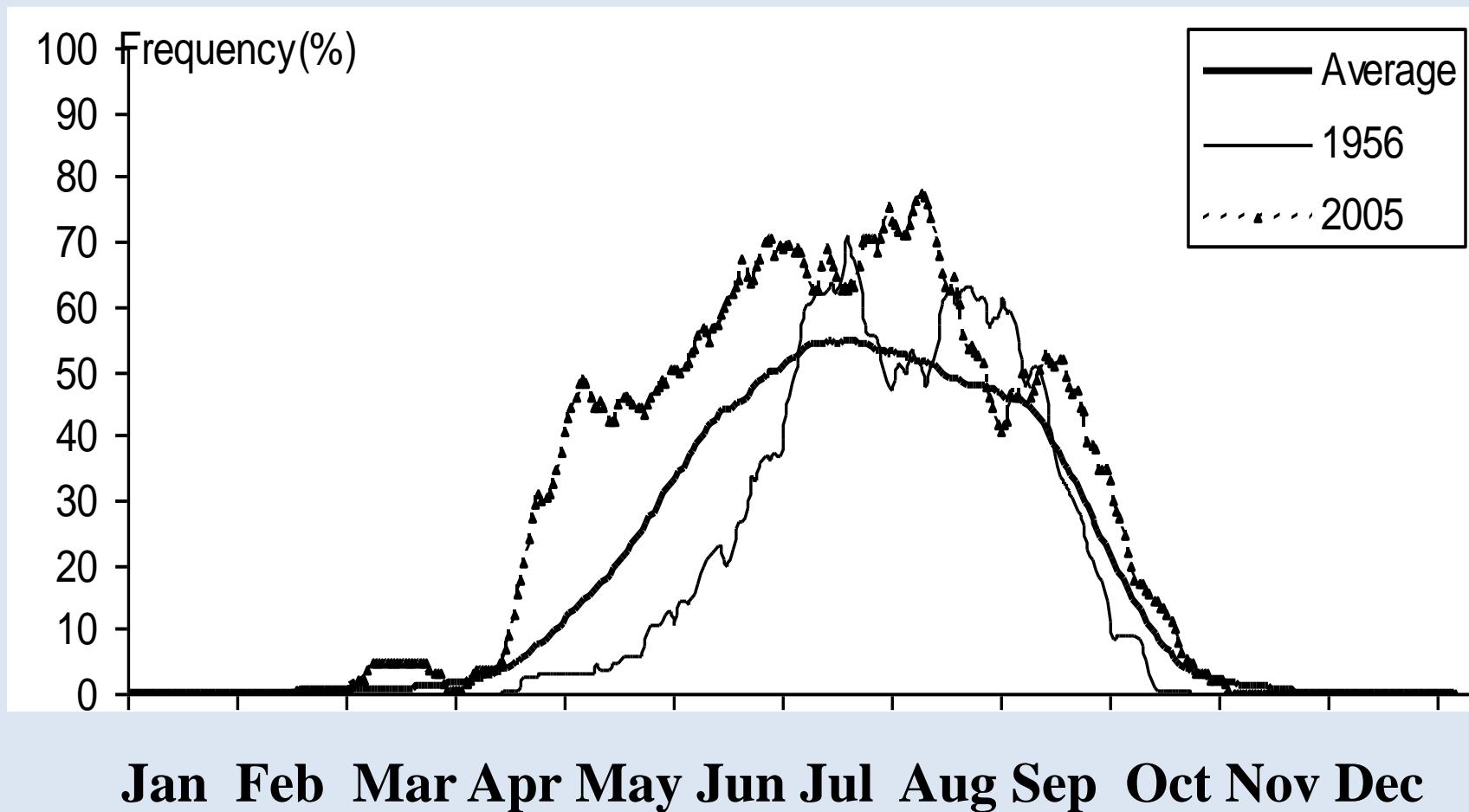
Winter



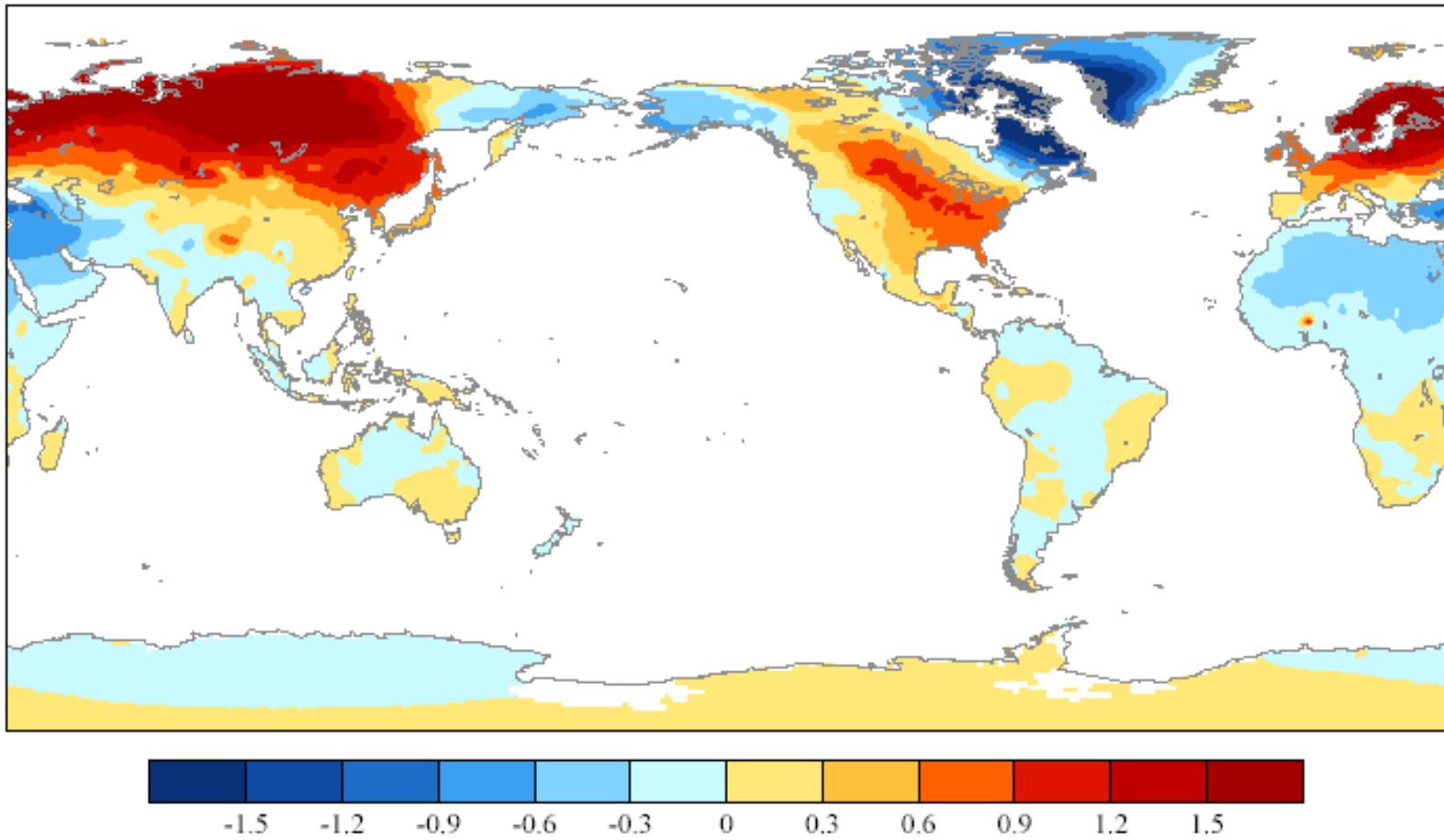
Temperature changes (°F) in Alaska: 1949-2009

Total Change in Mean Seasonal and Annual Temperature (°F), 1949 - 2009						
<i>Region</i>	<i>Location</i>	Winter	Spring	Summer	Autumn	Annual
Arctic <i>Interior</i>	Barrow	6.7	4.5	3.0	3.7	4.5
	Bettles	8.1	4.3	1.8	1.1	3.8
	Big Delta	8.9	3.4	1.2	0.0	3.4
	Fairbanks	7.4	3.6	2.3	-0.2	3.3
	McGrath	7.4	4.6	2.7	0.8	3.9
West Coast	Kotzebue	6.3	1.8	2.6	1.4	3.1
	Nome	4.2	3.3	2.5	0.4	2.6
	Bethel	6.6	4.8	2.3	0.0	3.5
	King Salmon	7.9	4.5	1.7	0.6	3.7
	Cold Bay	1.5	1.6	1.7	0.8	1.4
Southcentral	St Paul	0.8	2.1	2.6	1.1	1.6
	Anchorage	5.8	3.3	1.6	1.5	3.0
	Talkeetna	8.4	5.2	3.1	2.4	4.9
	Gulkana	7.7	2.4	1.0	0.1	2.8
	Homer	5.9	3.8	3.3	1.8	3.8
Southeast	Kodiak	0.7	2.1	1.2	-0.4	0.9
	Yakutat	4.6	2.8	1.8	0.4	2.5
	Juneau	6.2	2.9	2.2	1.4	3.2
	Annette	3.4	2.3	1.8	0.3	2.0
	Average	5.7	3.3	2.1	0.9	3.0

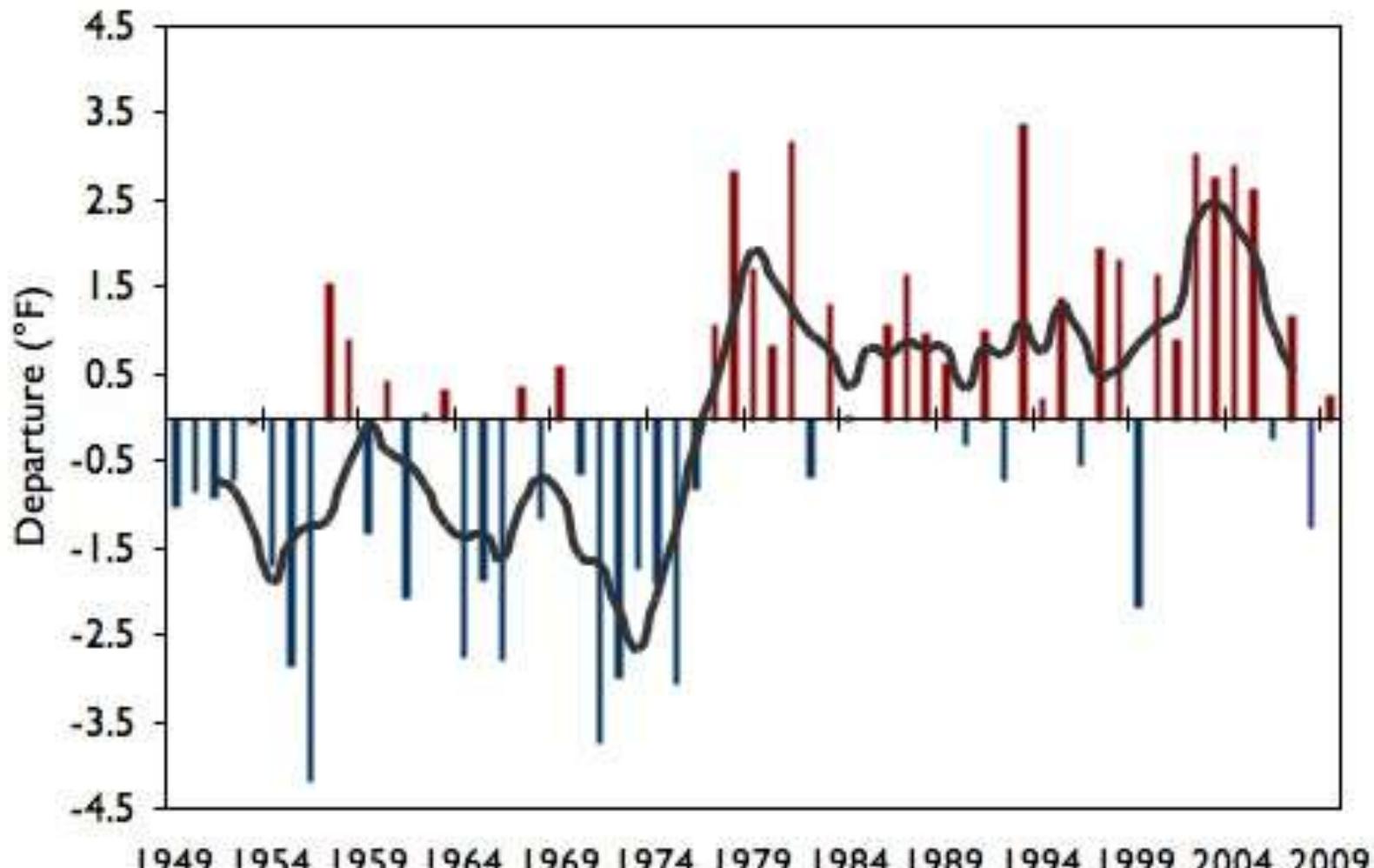
Seasonal frequency of weather conducive to sightseeing (King Salmon, AK)



Arctic Oscillation's contribution to recent winter temperature changes (from D. Thompson)



Mean Annual Temperature Departure for Alaska (1949 - 2009)



Alaska Climate Research Center

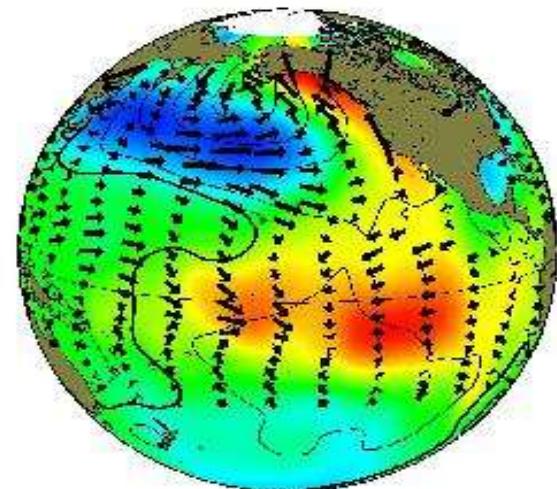
Geophysical Institute - UAF

(from Alaska Climate Research Center)

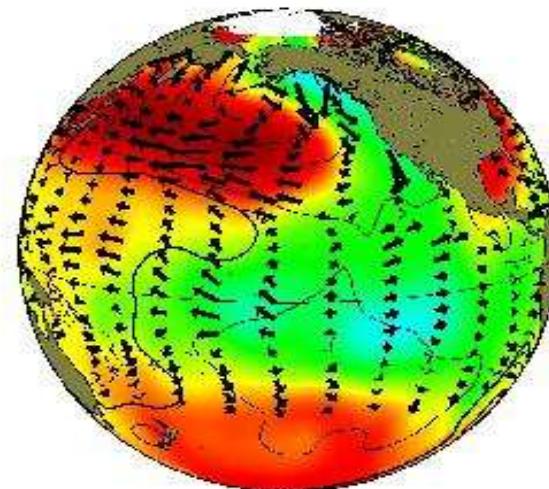
The Pacific Decadal Oscillation

[from JISAO, Univ. Of Washington]

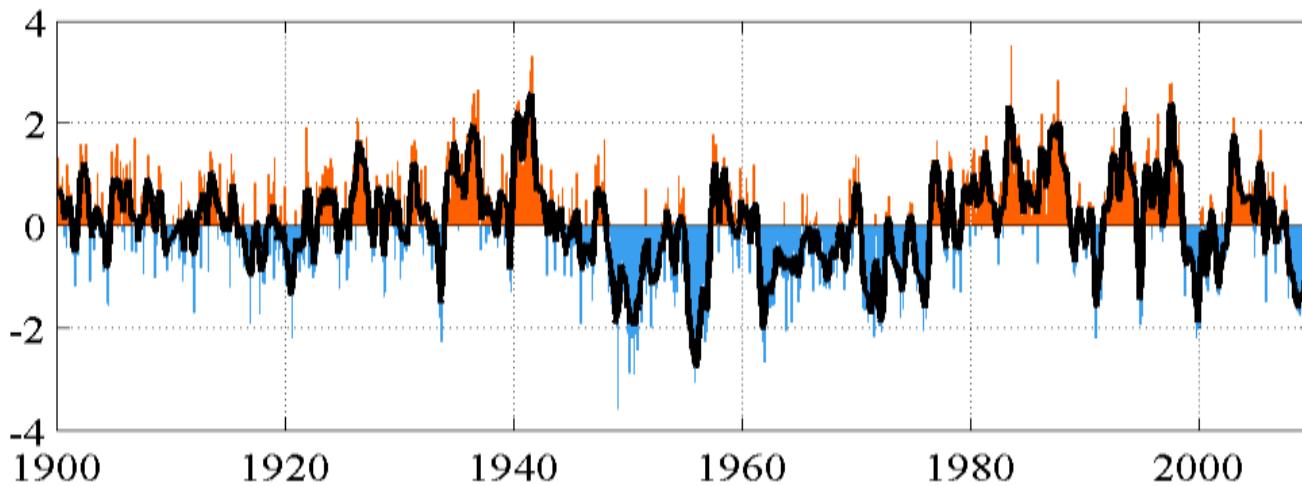
Alaska warm phase

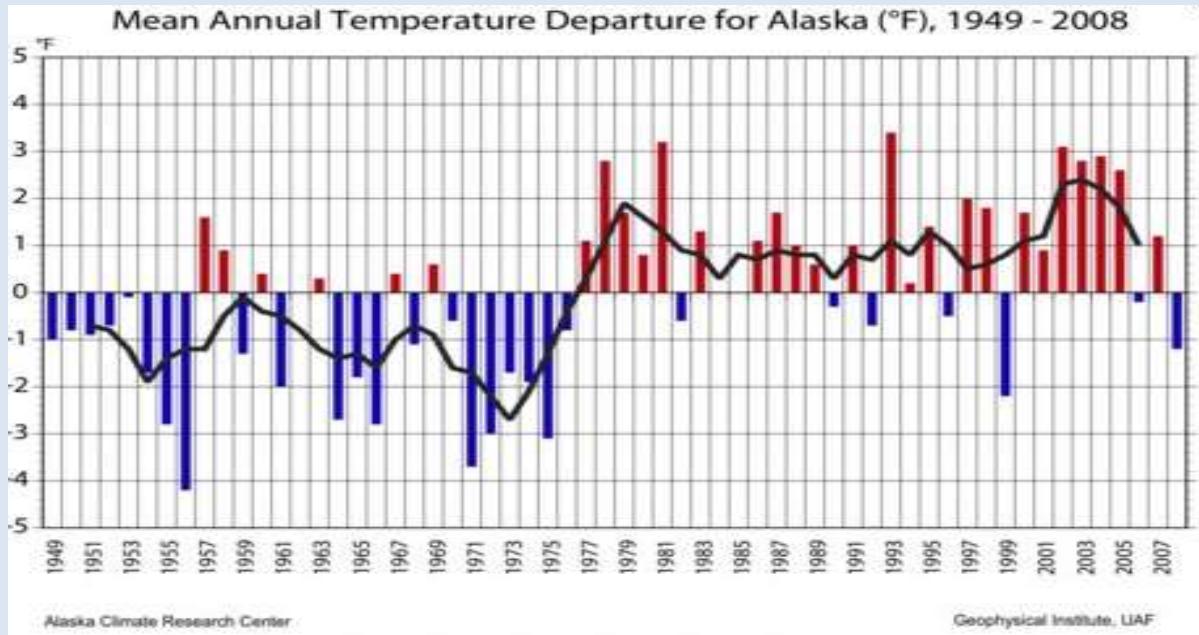


Alaska cold phase

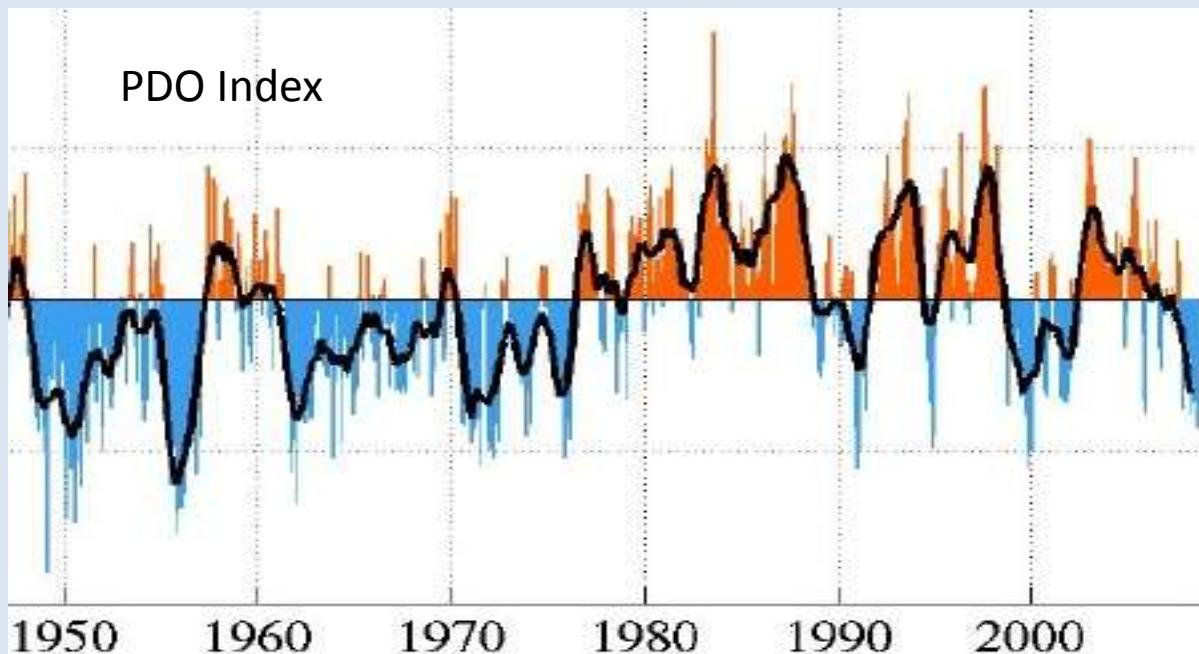


monthly values for the PDO index: 1900-September 2009





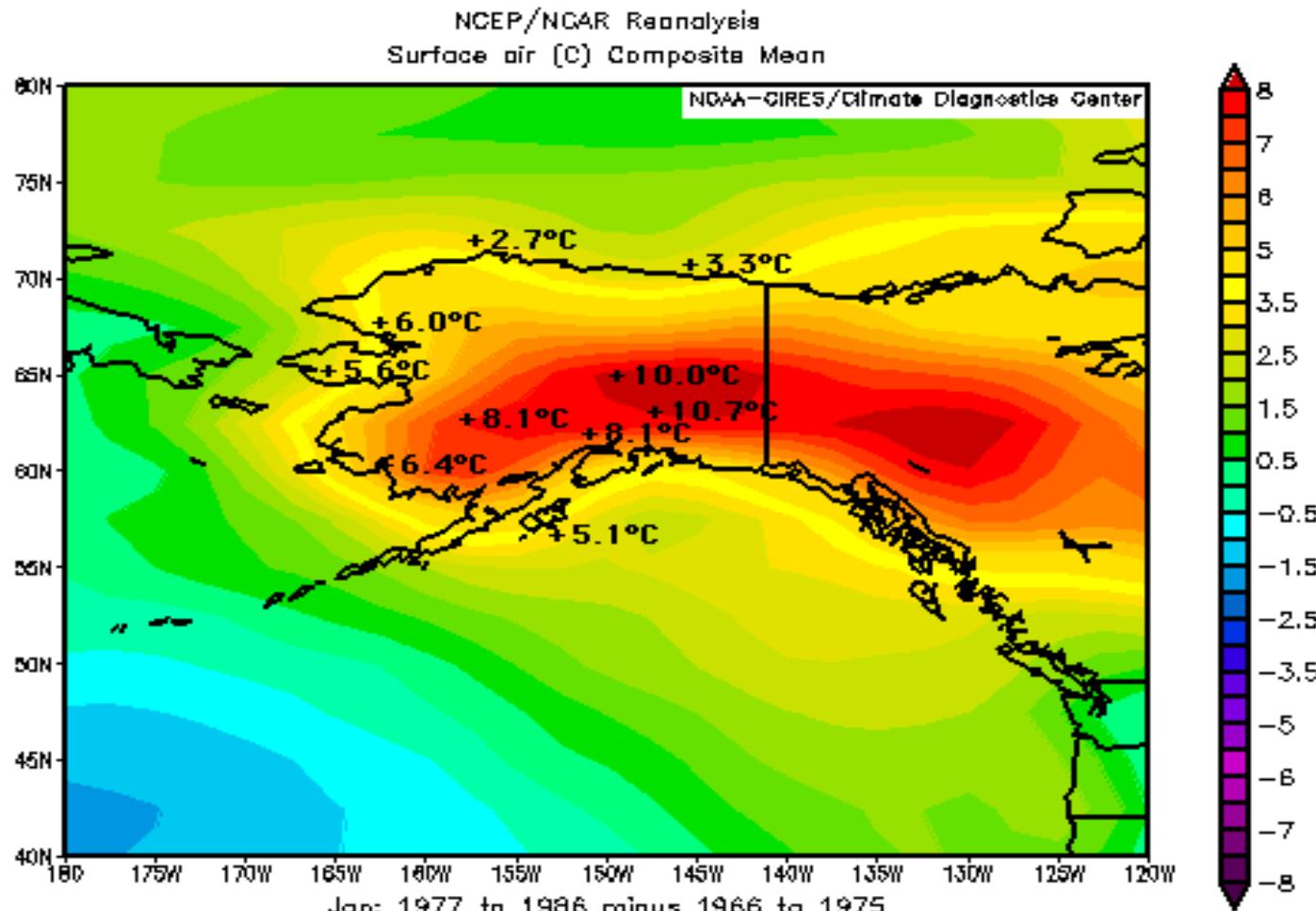
Alaska annual
temperature
anomalies



Pacific Decadal
Oscillation
Index

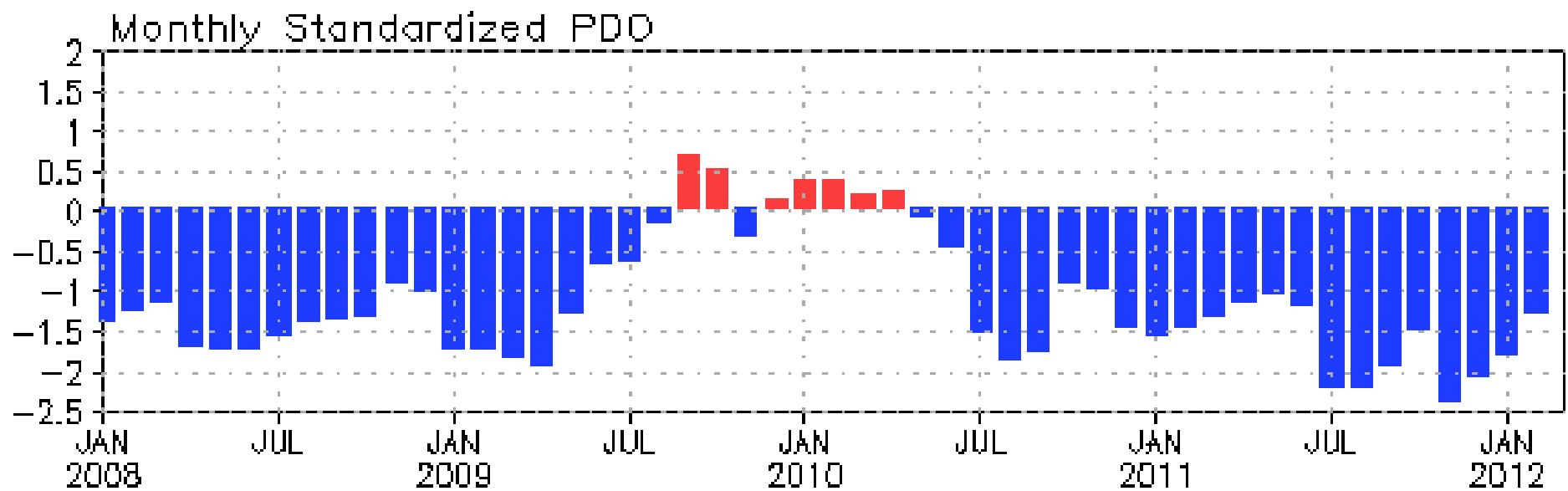
Effect of Pacific Decadal Oscillation shift (1976) on Alaskan temperature anomalies ($^{\circ}\text{C}$) *in January*:

1977-86 minus 1966-75



From B. Hartmann and G. Wendler, 2003
Alaska Climate Research Center

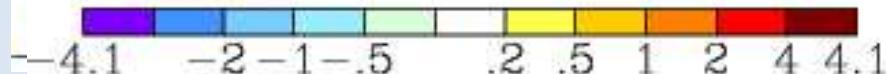
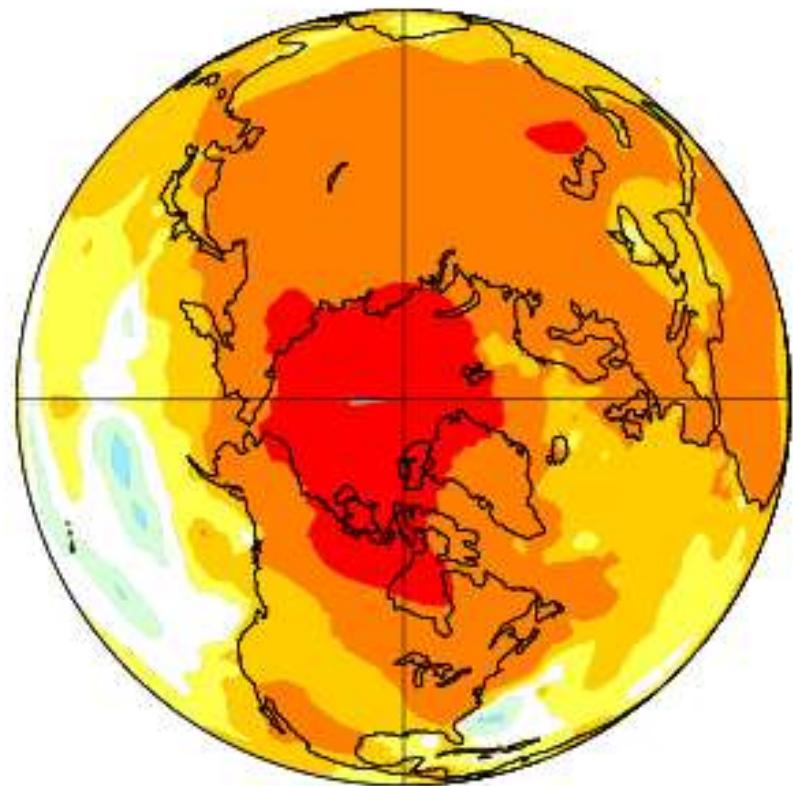
Pacific Decadal Oscillation Index: Jan. 2008 – Feb. 2012



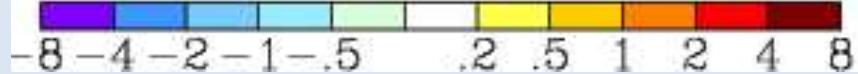
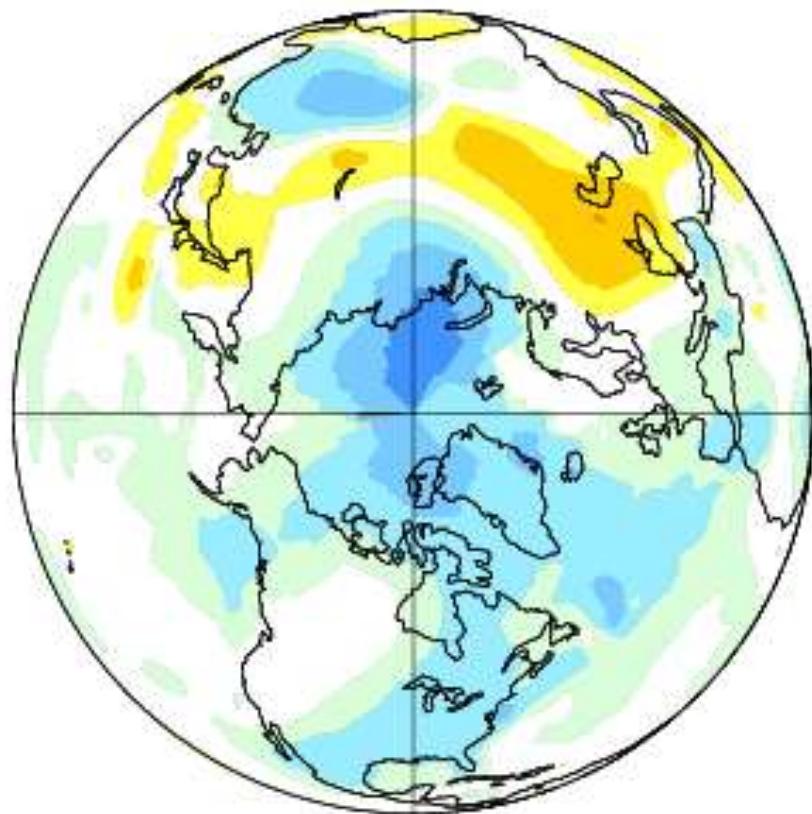
Change in surface air temperature ($^{\circ}\text{C}$)

[from NASA GISS]

1961-2010

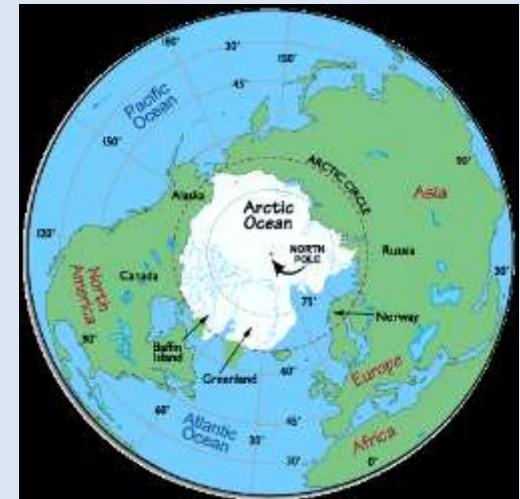


1941-1980



Climate projections based on global models

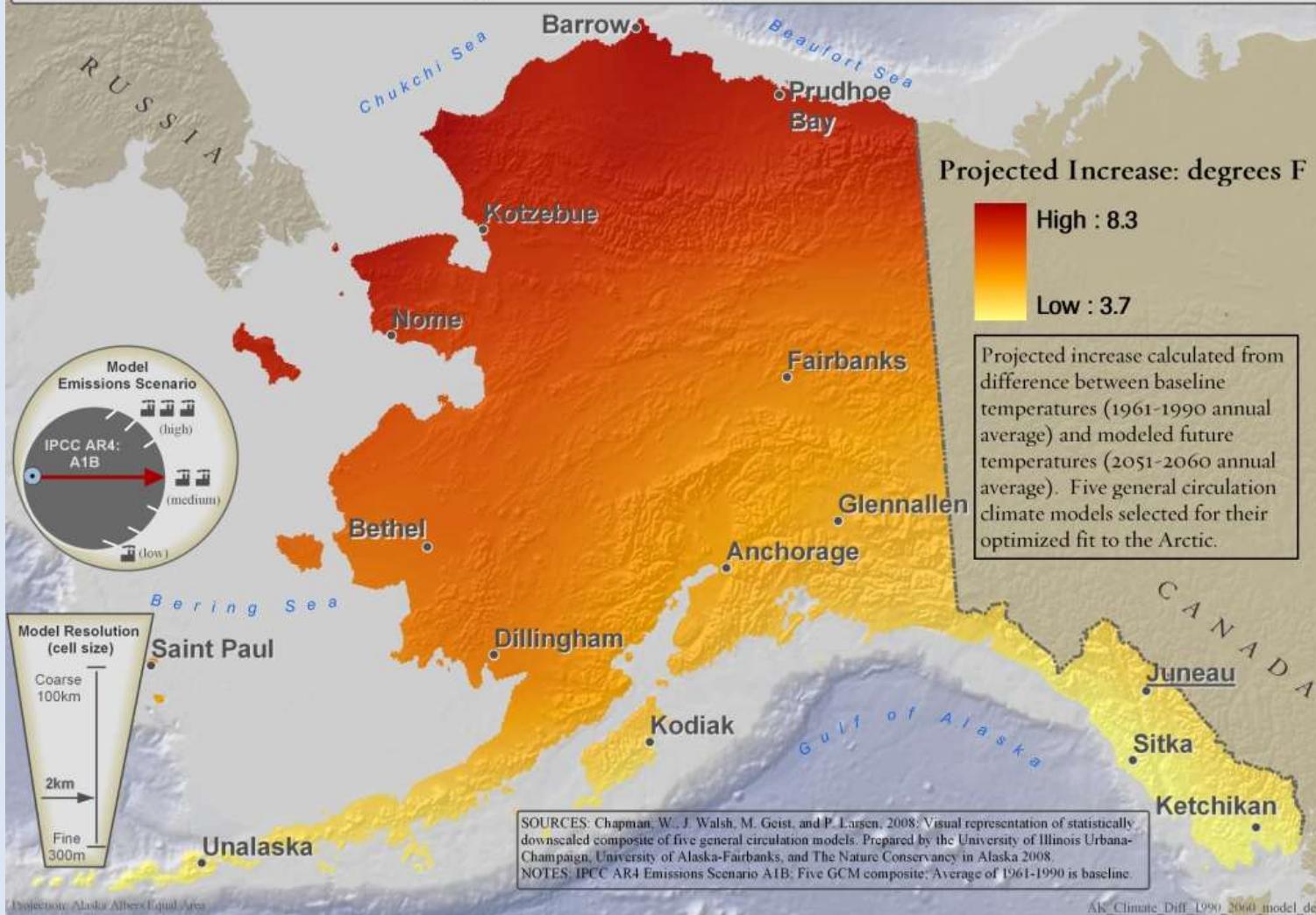
- A set of 15 models compared with data (1958-2000) for surface air temperature, sea level pressure, and precipitation
- Root-mean-square error (RMSE) evaluated over seasonal cycle to select the 5 best-performing models for Alaska,
- First focused on A1B (intermediate) scenario, then added B1 and A2
- Downscaled coarse-resolution GCM output to 2 km, now to 800 m



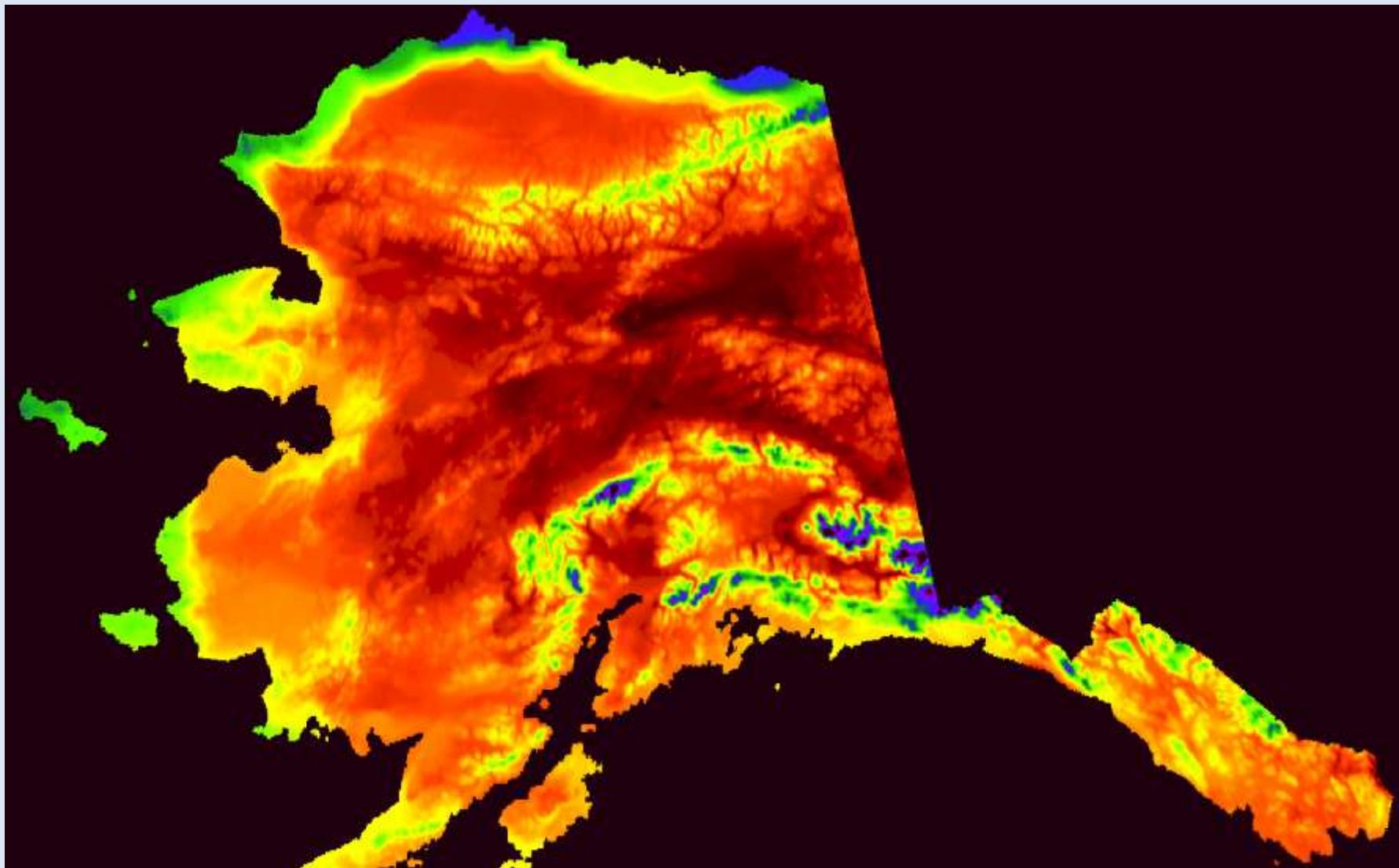
Downscaling by the “Delta” method

- A high-resolution climatology for a known reference period provides the base map
- A coarse-resolution climate model’s future changes from the model’s climatology for the same reference period is evaluated
⇒ the model’s “delta”
- The model’s delta is added to the high-resolution base map for the reference period
- Key point: Superimposed “delta” field is coarse, i.e., smooth; underlying climatology’s base map provides the spatial detail

Projected Change - Average Annual Temperature



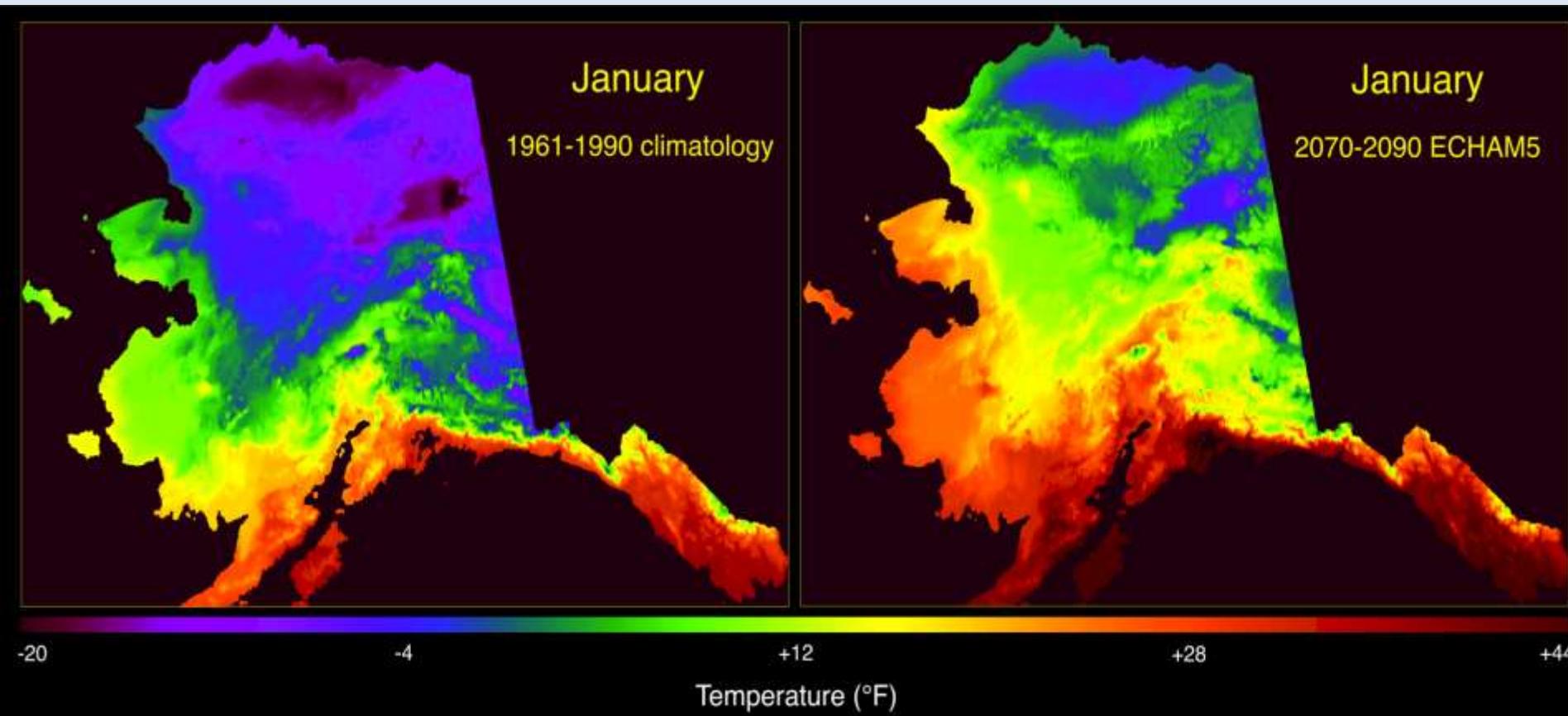
PRISM July T_{max} (1961-1990)
(deep red = 70s °F, blue = 40s °F)



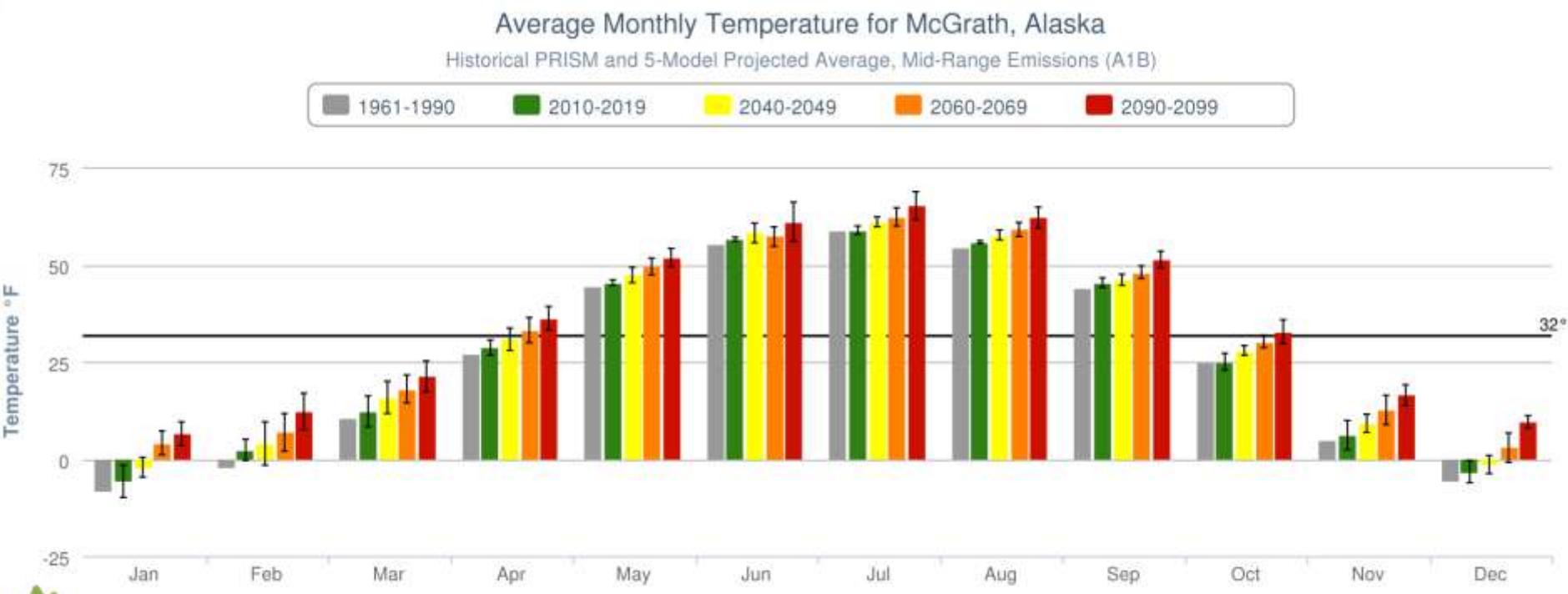
January Temperatures

1961-1990 (PRISM climatology)

2070-2090 (ECHAM5)



Monthly temperature projections for McGrath A1B (mid-range) scenario

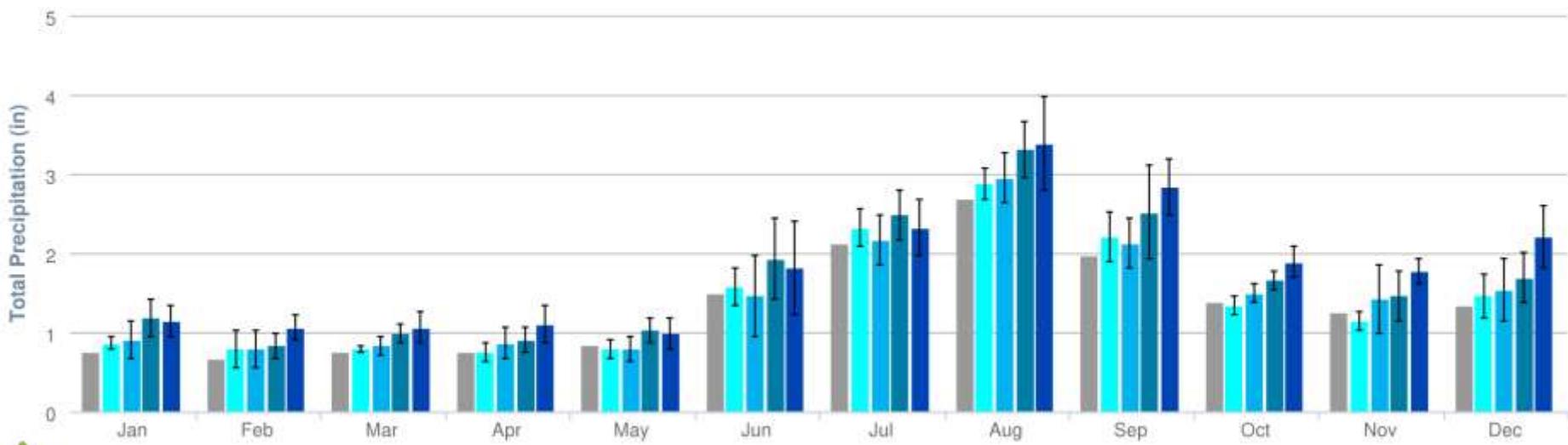


Sample of projections (A1B scenario): Fort Yukon temperatures by decade

FORT-YUKON												
66.5647 66.5681 214.7261 214.7170 0.520 KM												
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
<hr/>												
1961-1990	-20.3 (0.0)	-15.0 (0.0)	0.6 (0.0)	21.5 (0.0)	45.0 (0.0)	60.3 (0.0)	63.2 (0.0)	56.5 (0.0)	41.3 (0.0)	19.0 (0.0)	-7.3 (0.0)	-18.0 (0.0)
1991-2000	-17.9 (3.5)	-13.7 (1.2)	4.9 (2.1)	23.6 (3.3)	46.2 (1.4)	61.1 (1.3)	63.8 (0.7)	58.1 (0.4)	42.1 (1.1)	19.8 (0.9)	-5.2 (1.8)	-16.6 (2.8)
2001-2010	-16.4 (3.2)	-11.2 (3.7)	4.0 (1.6)	24.5 (2.1)	47.3 (1.9)	60.7 (1.3)	64.8 (1.7)	58.2 (1.0)	42.3 (1.0)	21.0 (1.7)	-4.2 (1.5)	-16.8 (2.3)
2011-2020	-16.0 (3.3)	-11.6 (2.3)	3.8 (4.0)	24.1 (2.1)	46.6 (0.9)	62.1 (1.3)	63.3 (1.5)	58.0 (1.1)	43.1 (1.0)	20.3 (2.1)	-4.6 (1.3)	-15.4 (2.0)
2021-2030	-12.9 (5.4)	-7.2 (3.6)	6.0 (2.3)	25.0 (3.2)	46.8 (0.6)	61.7 (1.5)	63.8 (1.7)	58.7 (1.8)	42.5 (1.1)	21.7 (2.4)	-3.9 (1.8)	-13.4 (2.9)
2031-2040	-13.3 (1.5)	-9.2 (4.5)	5.8 (4.1)	25.9 (2.6)	47.5 (1.5)	62.3 (1.3)	65.1 (2.5)	59.3 (2.0)	43.4 (1.4)	23.5 (2.4)	-0.1 (1.7)	-12.9 (2.4)
2041-2050	-10.9 (3.5)	-6.8 (3.7)	11.1 (3.2)	25.6 (3.0)	48.8 (2.1)	63.0 (1.9)	66.0 (1.7)	60.1 (1.5)	45.5 (2.1)	26.0 (2.0)	2.3 (1.5)	-9.3 (2.8)
2051-2060	-10.9 (4.3)	-4.5 (6.4)	7.5 (2.4)	27.2 (3.2)	48.4 (0.8)	63.8 (1.8)	66.5 (1.7)	60.5 (2.0)	45.1 (1.7)	25.4 (1.4)	1.8 (1.0)	-7.1 (2.1)
2061-2070	-6.8 (2.0)	-3.8 (3.6)	10.4 (4.2)	29.3 (3.1)	50.9 (2.5)	64.4 (3.4)	67.3 (3.1)	61.5 (2.3)	46.2 (2.4)	27.3 (2.1)	5.2 (3.1)	-6.0 (4.6)
2071-2080	-6.4 (1.9)	-3.4 (3.9)	10.8 (2.0)	29.3 (3.8)	51.3 (3.0)	64.3 (3.6)	67.7 (3.2)	62.7 (2.4)	46.9 (1.7)	27.8 (2.7)	5.3 (3.7)	-4.3 (3.9)
2081-2090	-3.8 (1.6)	-0.6 (3.3)	11.4 (3.6)	30.4 (3.6)	51.5 (2.3)	65.4 (3.5)	68.3 (2.2)	63.2 (2.6)	46.8 (1.7)	29.0 (1.2)	7.2 (2.6)	-2.7 (3.8)
2091-2100	-5.0 (2.9)	-1.6 (3.7)	13.4 (3.1)	31.5 (3.5)	52.7 (2.3)	65.2 (3.5)	69.0 (4.4)	63.4 (3.4)	48.4 (2.1)	28.9 (2.4)	7.1 (2.2)	-0.1 (3.0)

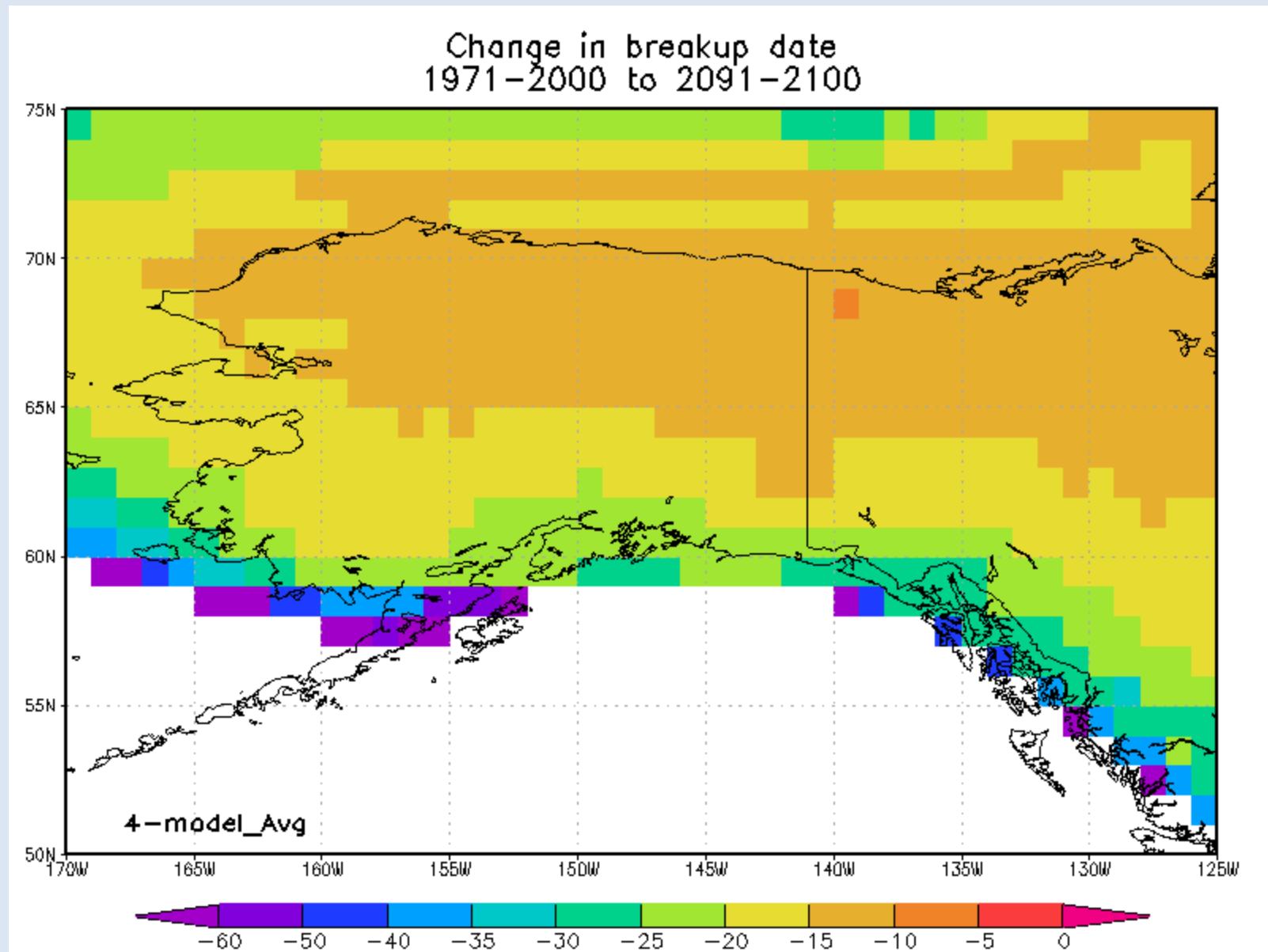
Projected monthly precipitation for McGrath

Average Monthly Precipitation for McGrath, Alaska
Historical PRISM and 5-Model Projected Average, Mid-Range Emissions (A1B)

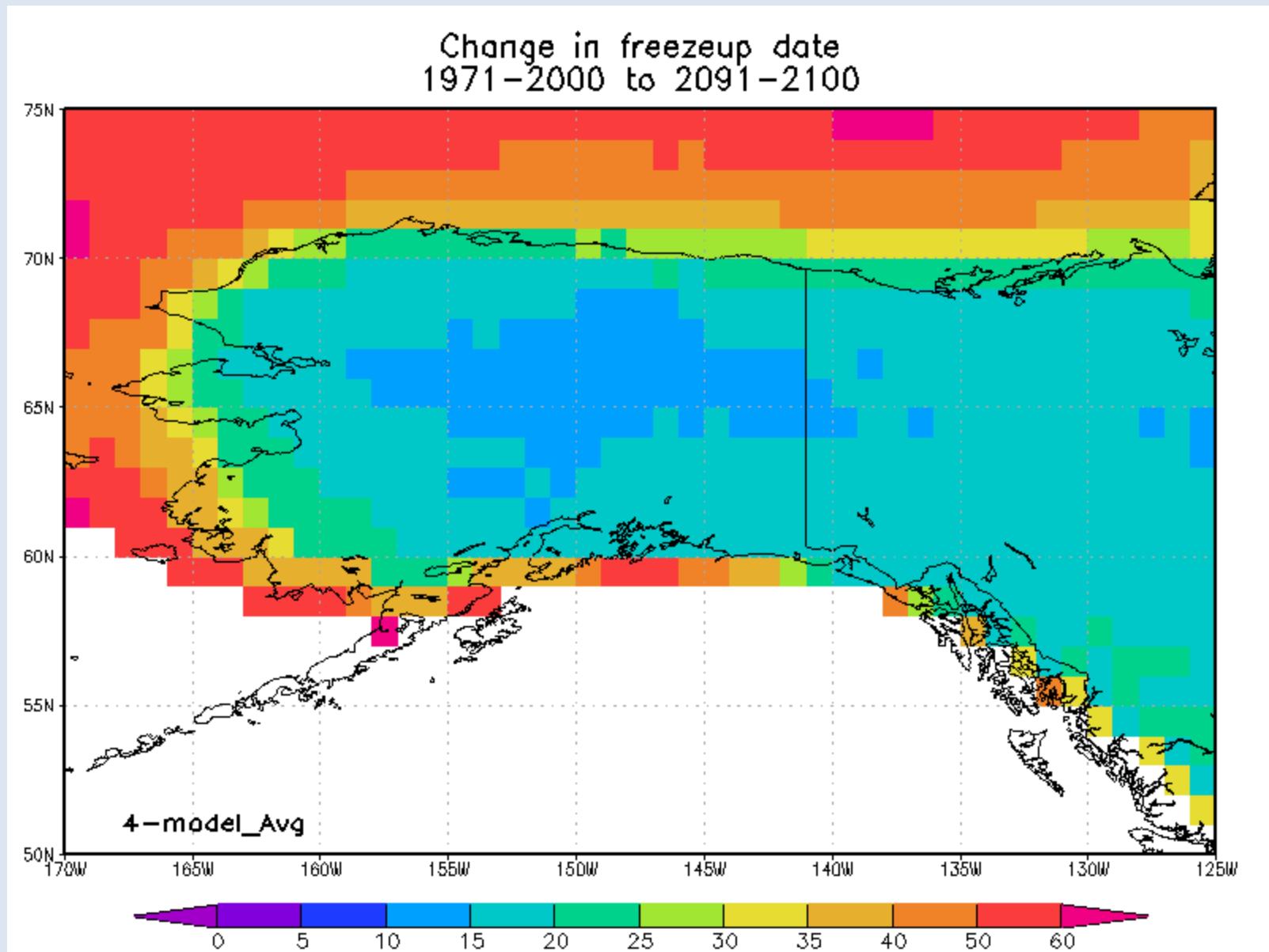


Due to variability among climate models and among years in a natural climate system, these graphs are useful for examining trends over time, rather than for precisely predicting monthly or yearly values. For more information on derivation, reliability, and variability among these projections, please visit www.snap.uaf.edu.

IPCC model projections of change in thaw date by 2091-2100



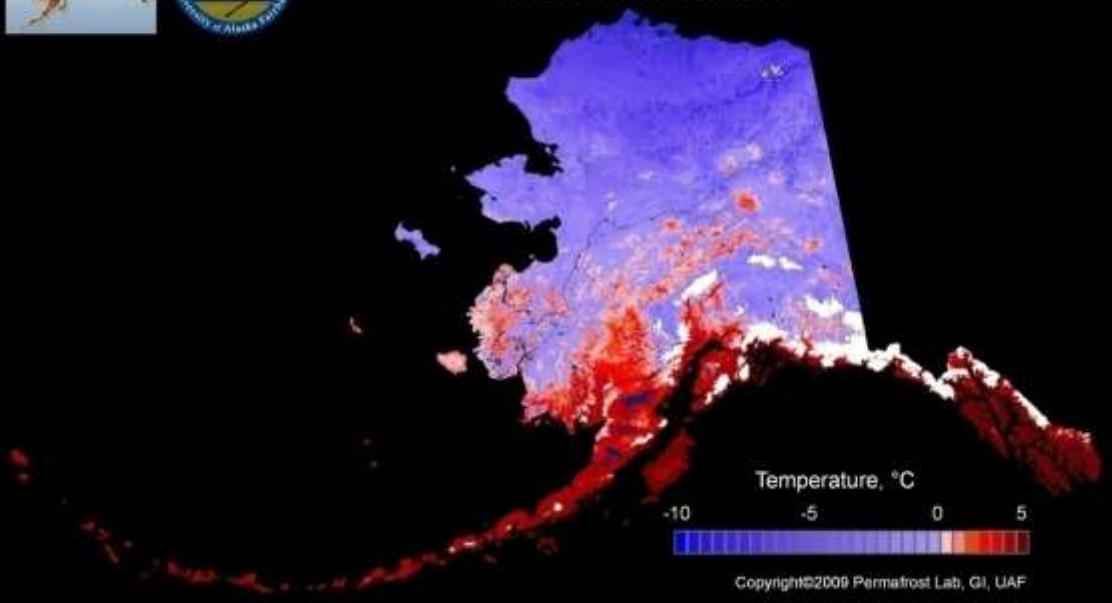
IPCC model projections of change in freeze-up by 2091-2100





Mean Annual Soil Temperatures at 2 m Depth
ALASKA 2000-2009

GIPL1.3 Permafrost Model



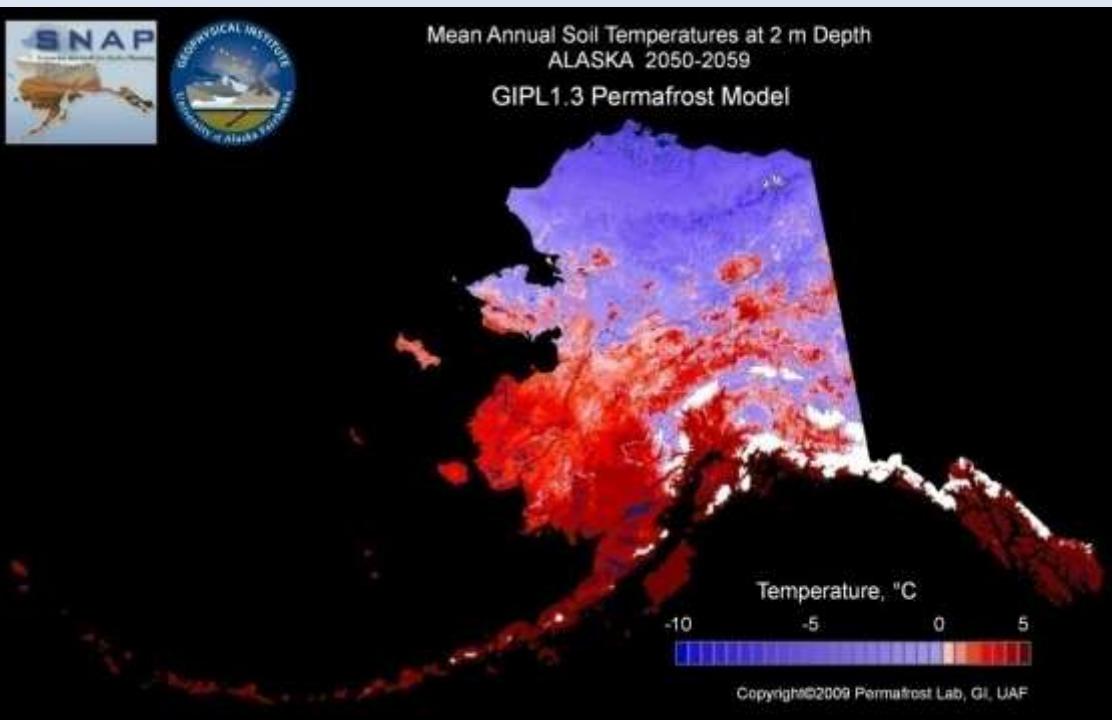
Mean annual soil temp.
(2 m depth)

← 2000-2009



Mean Annual Soil Temperatures at 2 m Depth
ALASKA 2050-2059

GIPL1.3 Permafrost Model



← 2050-2059

Summary

- **Alaskan climate is changing, but variability dominates changes over timeframes up to a decade or two**
- **Key concerns arise from cumulative climatic effects**
e.g., on vegetation, permafrost, glaciers, ...
- **A “wild card”: Effects of climate change on extreme events**